



Government Actions and Innovation in Environmental and Renewable Energy Technologies

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Motivation

- ✱ Global climate change mitigation vs. economic growth
 - Environmental and renewable energy technologies hold promise
- ✱ Innovation in these technologies is different
 - Weak market incentives for private investment
 - Strong role for government in promoting innovation
- ✱ How to design future government actions to promote innovation in these technologies?
 - Learn from the past

Today's Road Map

1. Research Approach
2. Case Studies:
 - Selective Catalytic Reduction (SCR)
 - Wind Power Generation
3. Conclusions

Literature Review

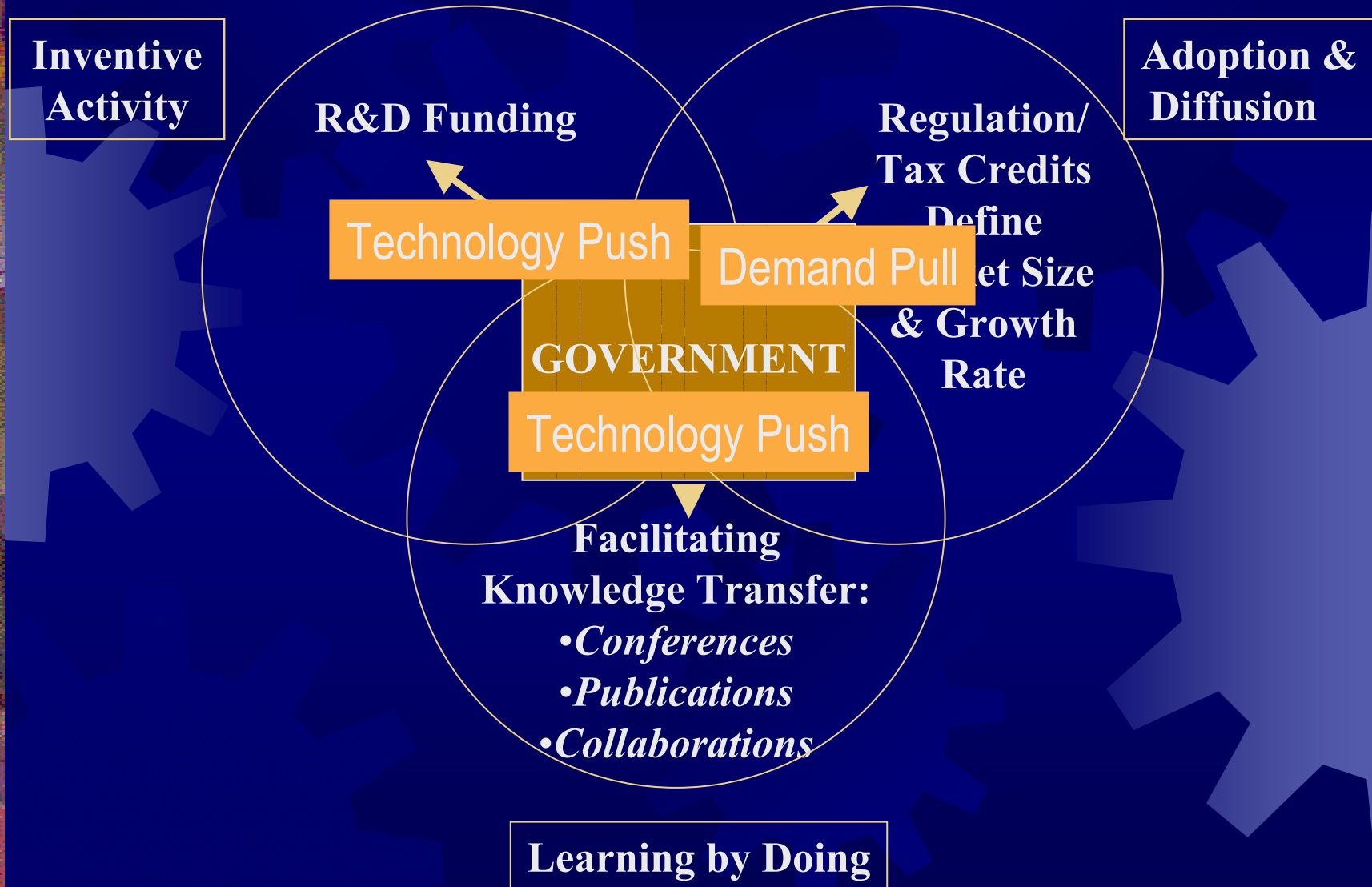
★ Mainstream Innovation Literature

- Approaches: Aggregate, multi-industry empirical economic studies (some more focused case studies)
- Themes: Role of demand-pull & technology-push in driving innovation; inducement mechanisms for innovation

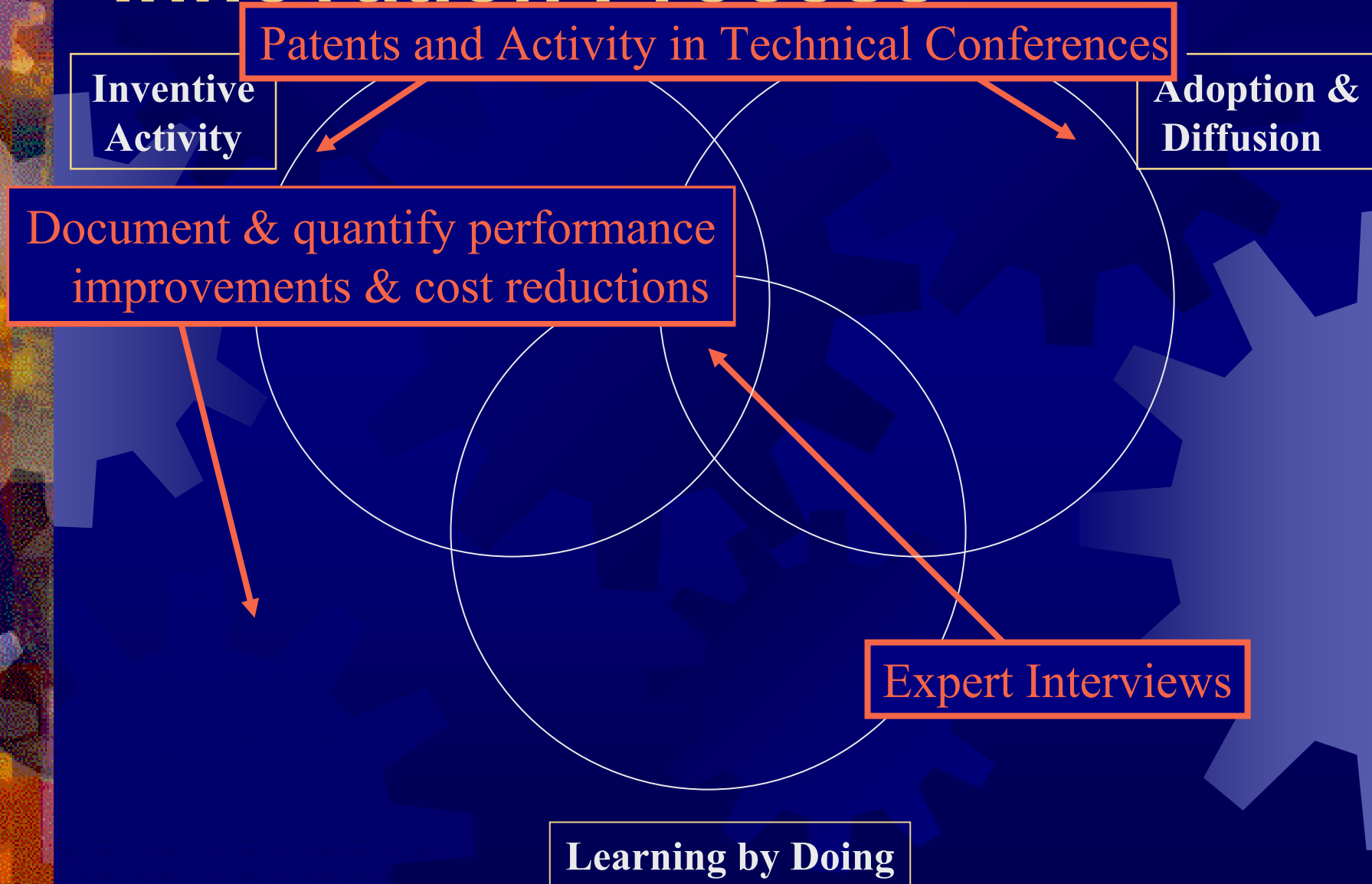
★ Environmental Technology Literature

- Approaches: Several theoretical economic studies, a few large empirical economic studies, a few case studies
- Themes: Porter Hypothesis. Role of regulatory stringency, flexibility, uncertainty in driving innovation

Government in the Innovation Process



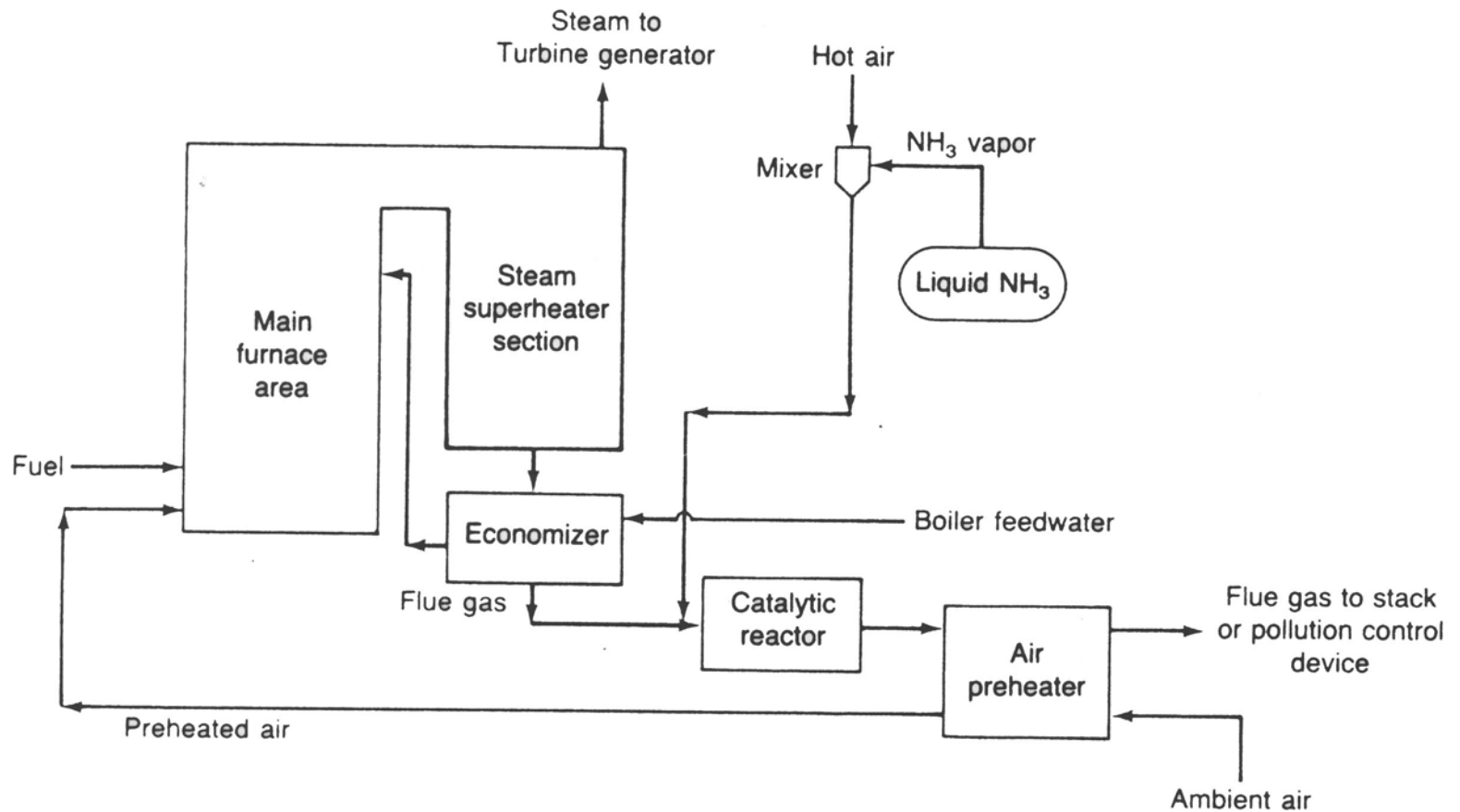
Research Approach to the Innovation Process



Case Studies

- ✱ **Selective Catalytic Reduction (SCR) for NO_x Control from Stationary Sources**
- ✱ **Wind Power Generation**
- ✱ **Selection Criteria:**
 - ✱ Relevant to GHG emissions
 - ✱ Long history and data
 - ✱ Significant innovation in the technology
 - ✱ CA played important role

NO_x Control in CA Energy

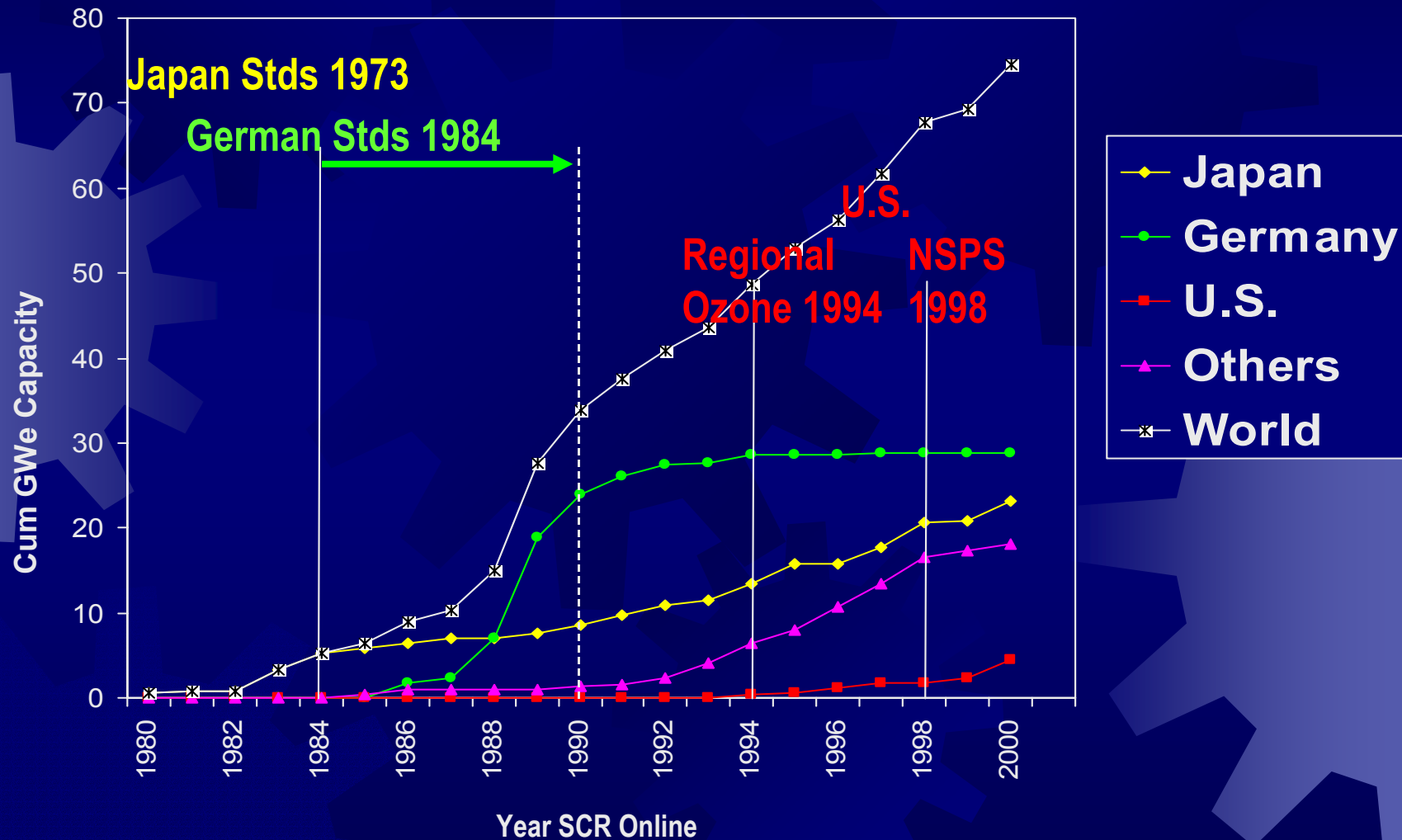


Source: Cooper and Alley 1994

Government Actions in SCR (Pull)

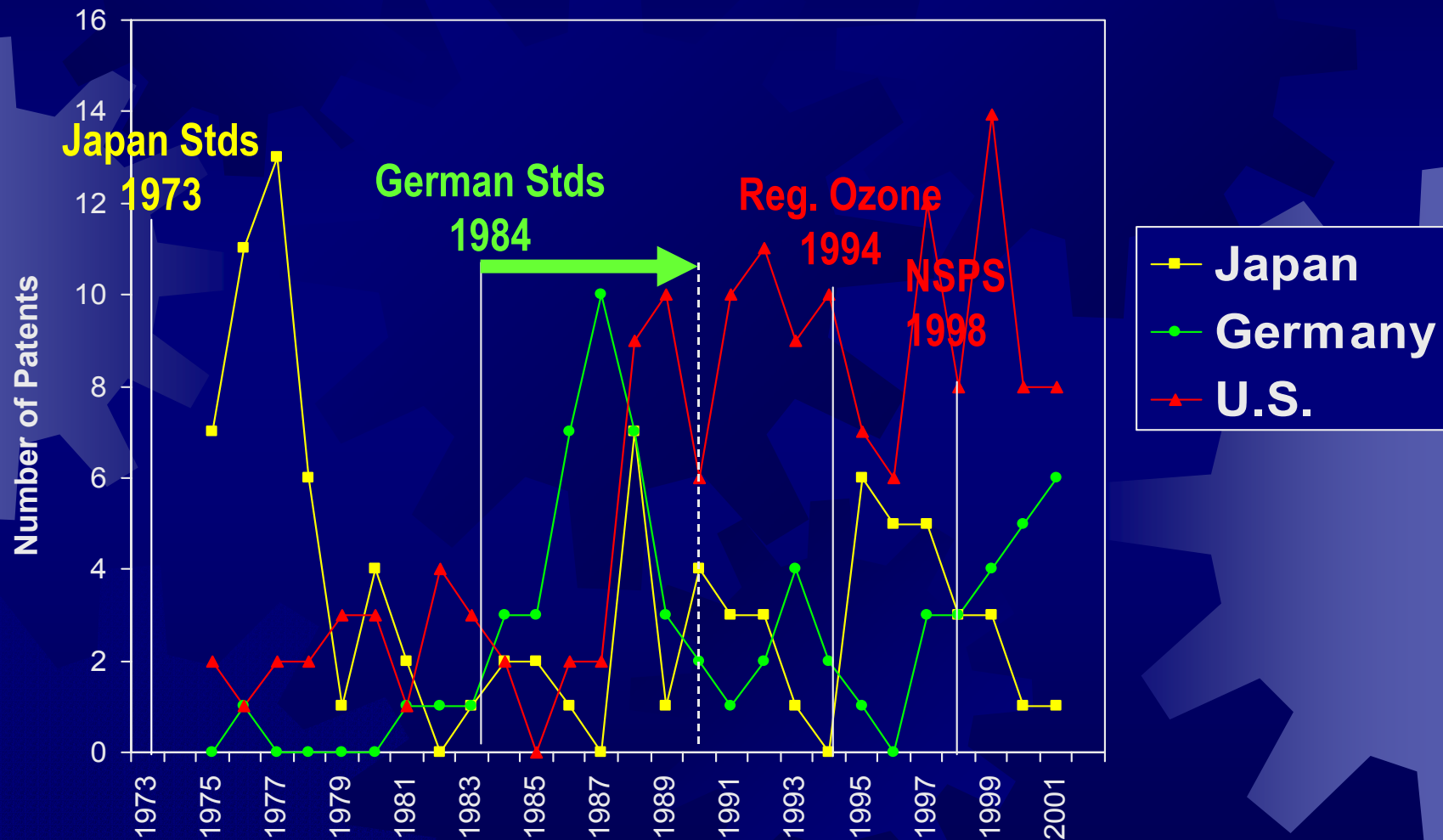
Location/Date Type of Action (Action)	Description
U.S.: CA 1950s-60s Permitting authority	No capacity increases without abatement plan (required R&D)
Japan 1973 Standards	50-60% Reductions
Germany 1984 Standards	60-80% Reductions (0.15 lbs/Mbtu) New & existing coal-fired, by 1990
U.S.: CA 1989-90 Standards(SCAQMD 1135)	0.015 lb/Mbtu Utility boilers (other rules for other sources)
U.S. 1994-98 Standards (Regional Ozone and Market)	0.15 lb/Mbtu By 2003 (starts 12 NE states+DC, now 22 states)
U.S. 1998 Standards (NSPS)	80% Reductions New & modified (mostly coal)

Diffusion in SCR



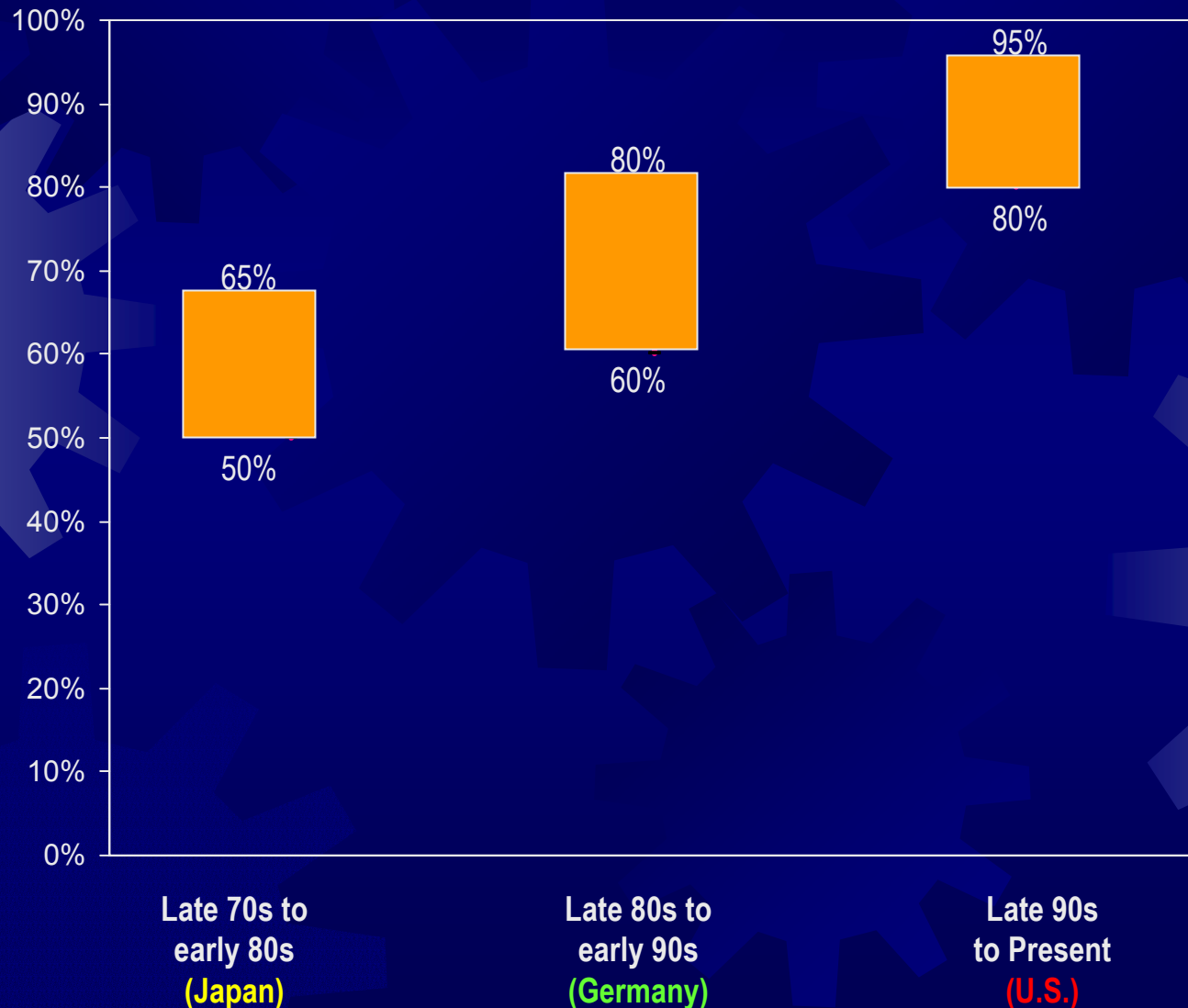
SCR Outcomes 1

Patents vs. Government Actions

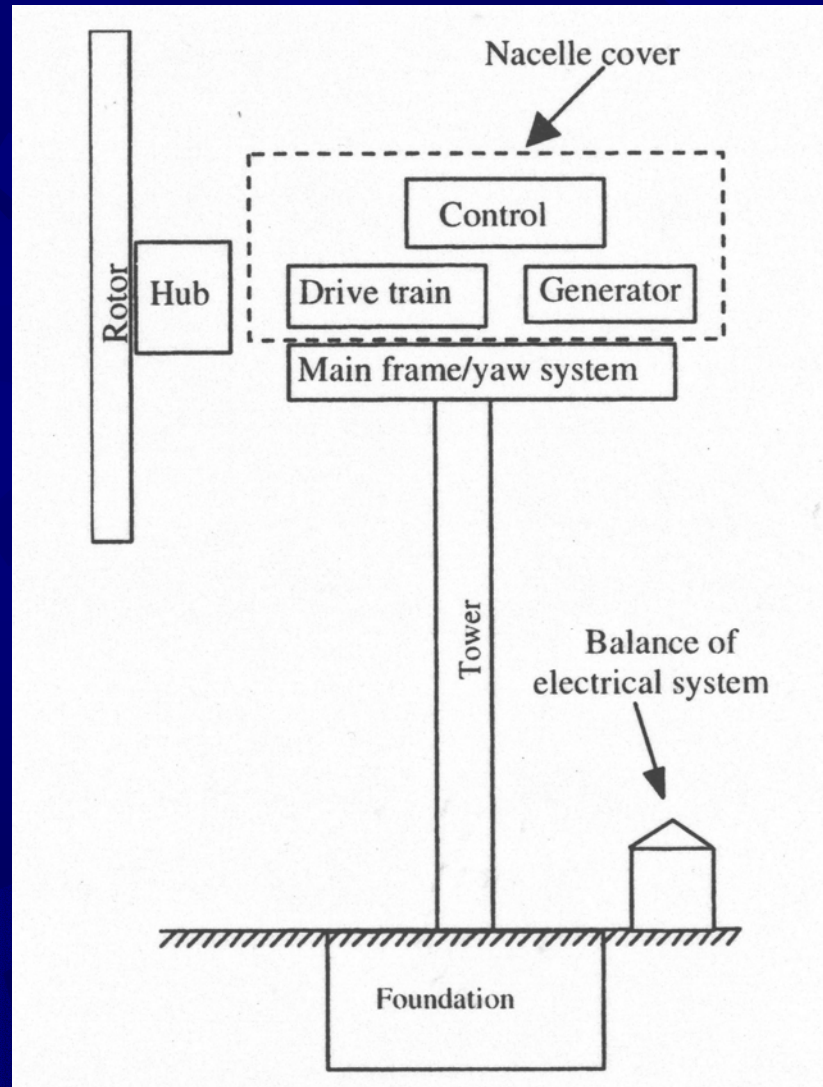


SCR Outcomes 2

Improvement in Removal Efficiencies



Wind Power in CA Energy

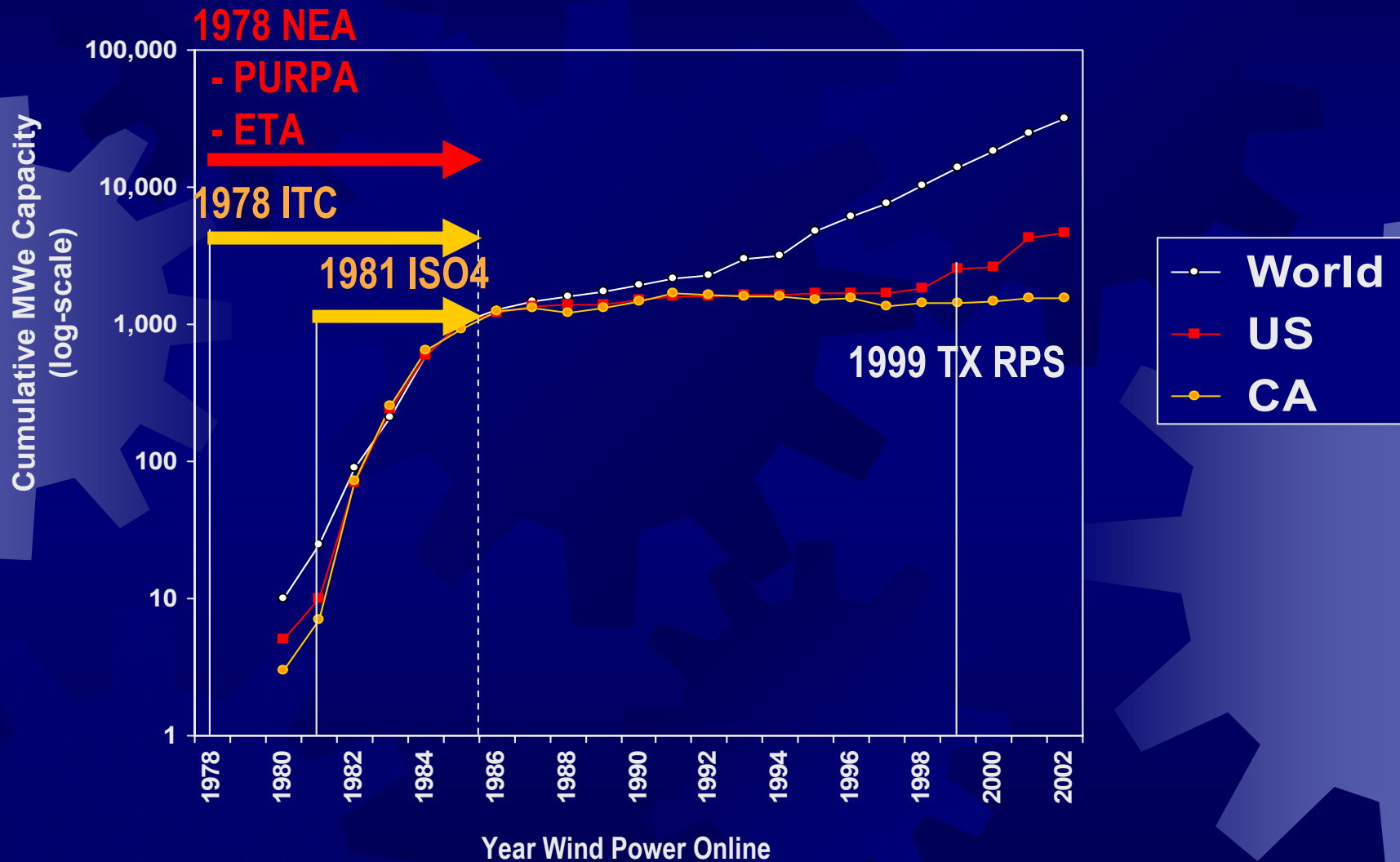


Source:
Manwell et al. 2002

U.S. Government Actions in Wind (Pull)

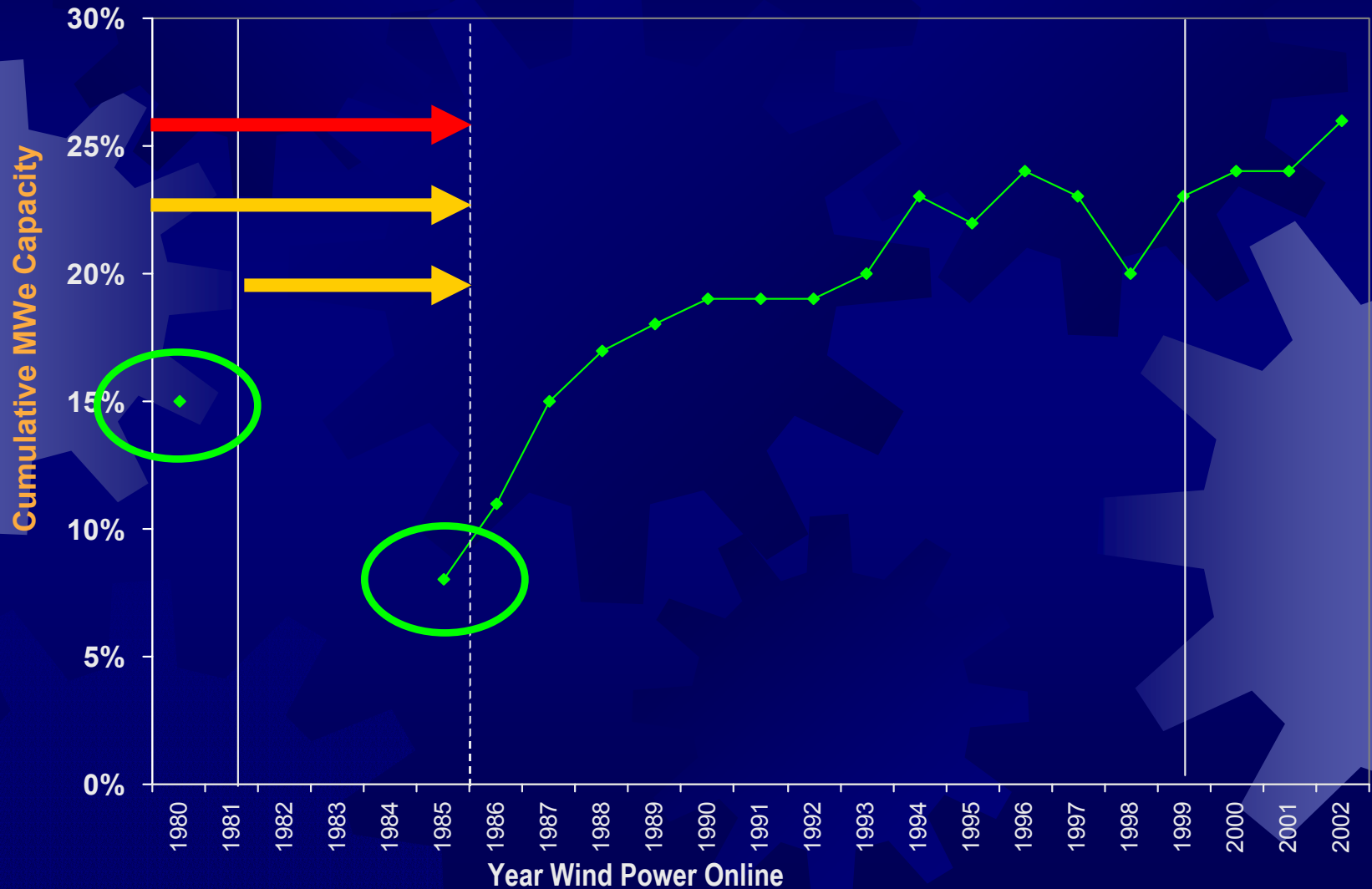
Date/Loc.	Action	Description
1978 Fed.	National Energy Act (NEA) <ul style="list-style-type: none">☀ PURPA☀ Energy Tax Act (ETA)	5-part legislation <ul style="list-style-type: none">☀ Req'd utilities to buy power at avoided cost, sell back-up at non-discriminatory rates☀ Tax credits for wind (bus. & res.); bus. later increased and extended to end of 1985
1978 CA	Investment Tax Credit	25% (w/ETA, almost 50%)
1981 CA	Interim Standard Offer No. 4 Contracts (ISO4)	Guaranteed an effective tariff of \$0.12 per KWh
1992 Fed.	Production Tax Credit (PTC)	\$0.015 per kWh for power from wind at Qualified Facilities
1999 TX	Renewable Portfolio Standard (RPS)	By 2009, mandated installation of 2,000 MWe. Long term contracts average \$0.03 per kWh (+ fed PTC).

Diffusion in Wind



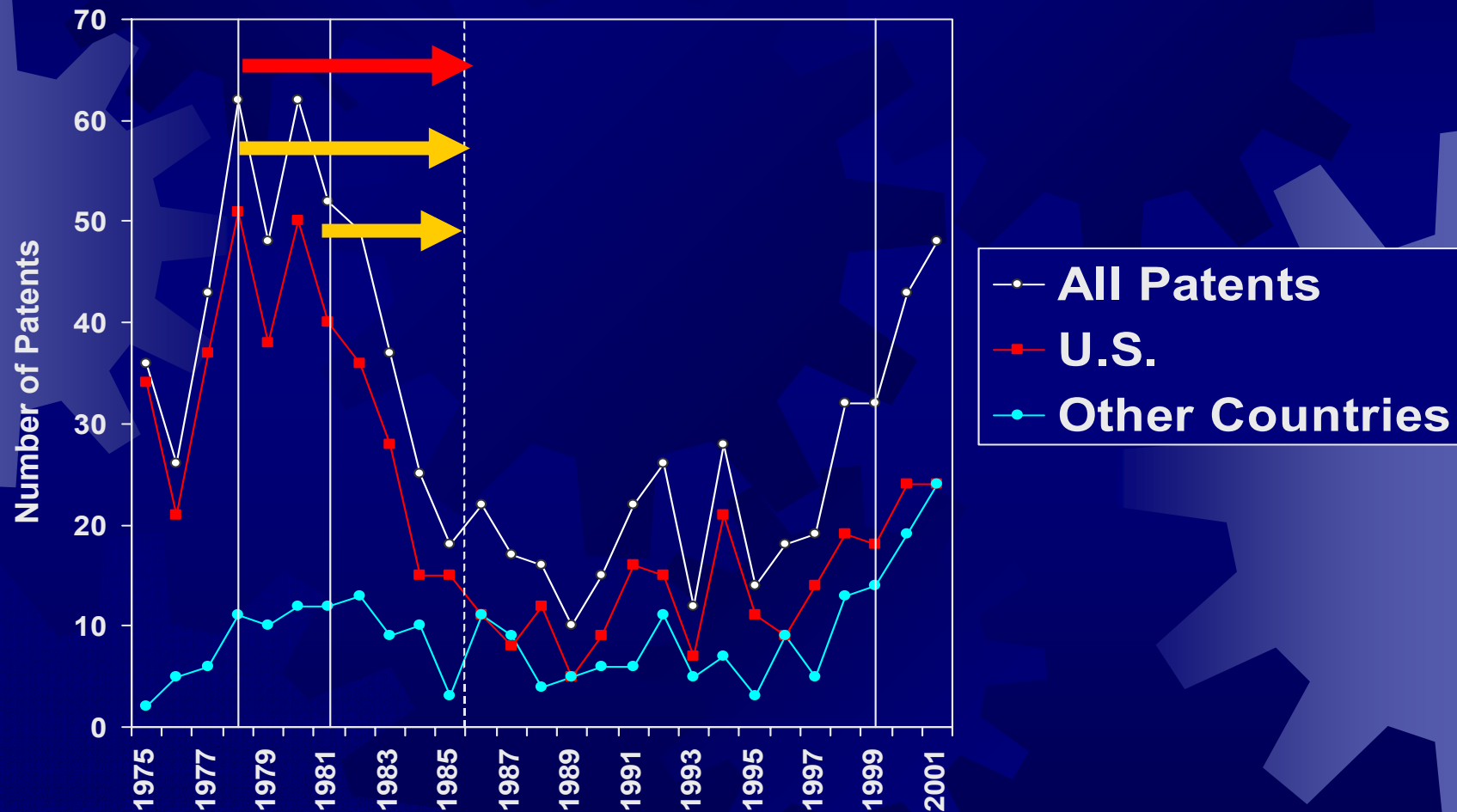
Wind Outcomes 1

CA Capacity Factor



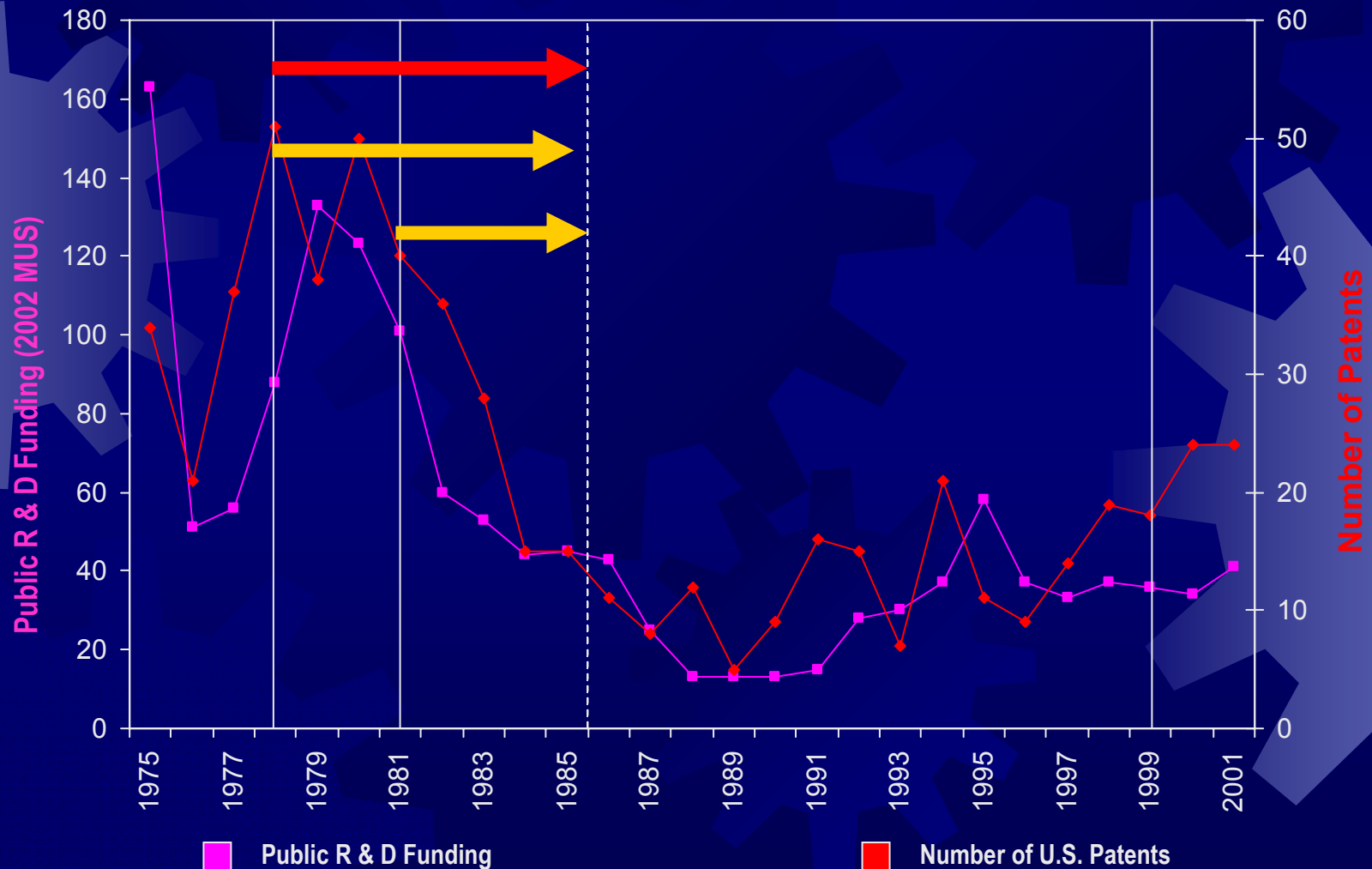
Wind Outcomes 2

U.S. Patents vs. U.S. Government Actions



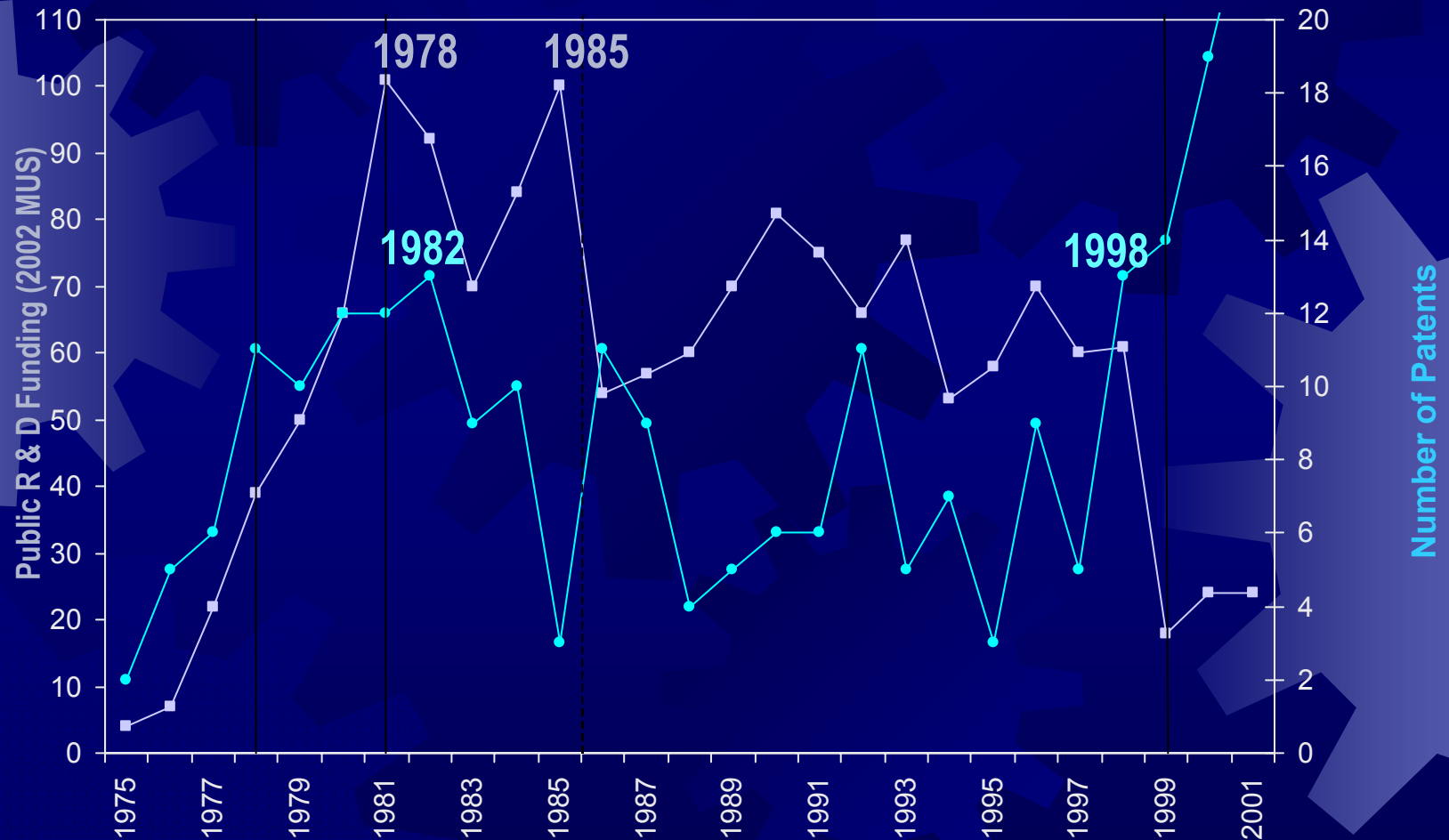
Wind Outcomes 3

U.S. Patents, U.S. Public R&D (Push)



Wind Outcomes 4

“Foreign” U.S. Patents, Non-U.S. Public R&D





Operating Experience

SCR and Wind – Horror Stories

Operating Experience

SCR and Wind – Horror Stories

- ✱ Initial commercial application - unforeseen problems
 - Problems of plugging and poisoning of catalyst in SCR
 - Catastrophic failures of large wind turbines
- ✱ Solutions
 - Learning-by-doing (incremental)
 - Boundary spanning (draw from other industries/technologies)
 - Knowledge transfer between nations, organizations, facilities
- ✱ Government role?
 - Facilitate knowledge transfer
 - First mover *disadvantage* barrier to innovation is market failure, good place for government to intervene

Optimal Government Actions to Promote Environmental Innovation

